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H04Q 7/36

(52) UK CL (Edition N)
H4L LDSE L1H10

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GB 2260242 A EP 0544095 A1 EP 0430173 A2
EP 0419243 A2 WO 92/11736 A1 WO 91/09474 A1

(58) Field of Search
UK CL (Edition M) H4K KY4D14 KY4D8D, H4L LDSF
INT CL^5 H04Q 7/04
ONLINE DATABASE:WPI

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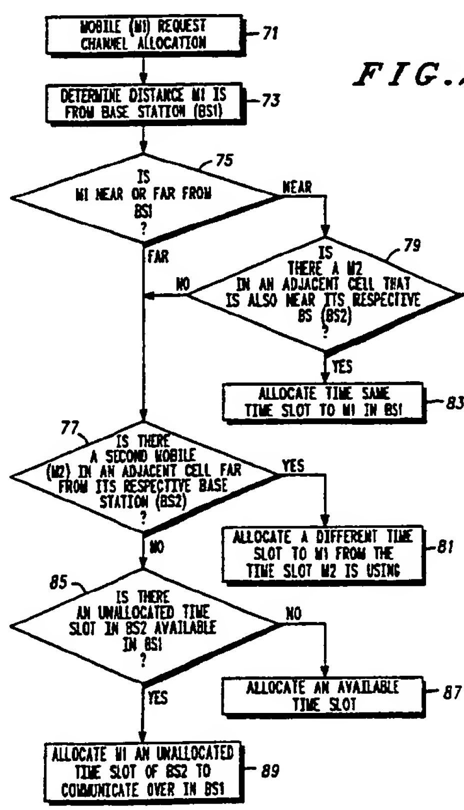
(54) Communications system

(57) A method for allocating a communications resource such as a time slot or channel to a mobile unit in a communications system for a first mobile unit to communicate over on the basis of a parameter (e.g. the transmit power level or distance from a base station) of that unit. The communications resource for a second mobile unit is allocated based on a parameter of the second mobile unit and the parameter of the first mobile unit. In the cellular radio system described base stations exchange information directly or via mobile switching centres including parameters of their respective mobile units and the communications resources allocated to those mobile units. Time slots and/or channels are allocated to mobile units based on the power levels and/or positions of those mobiles and mobiles in adjacent cells to minimise interference therebetween.

FIG.2



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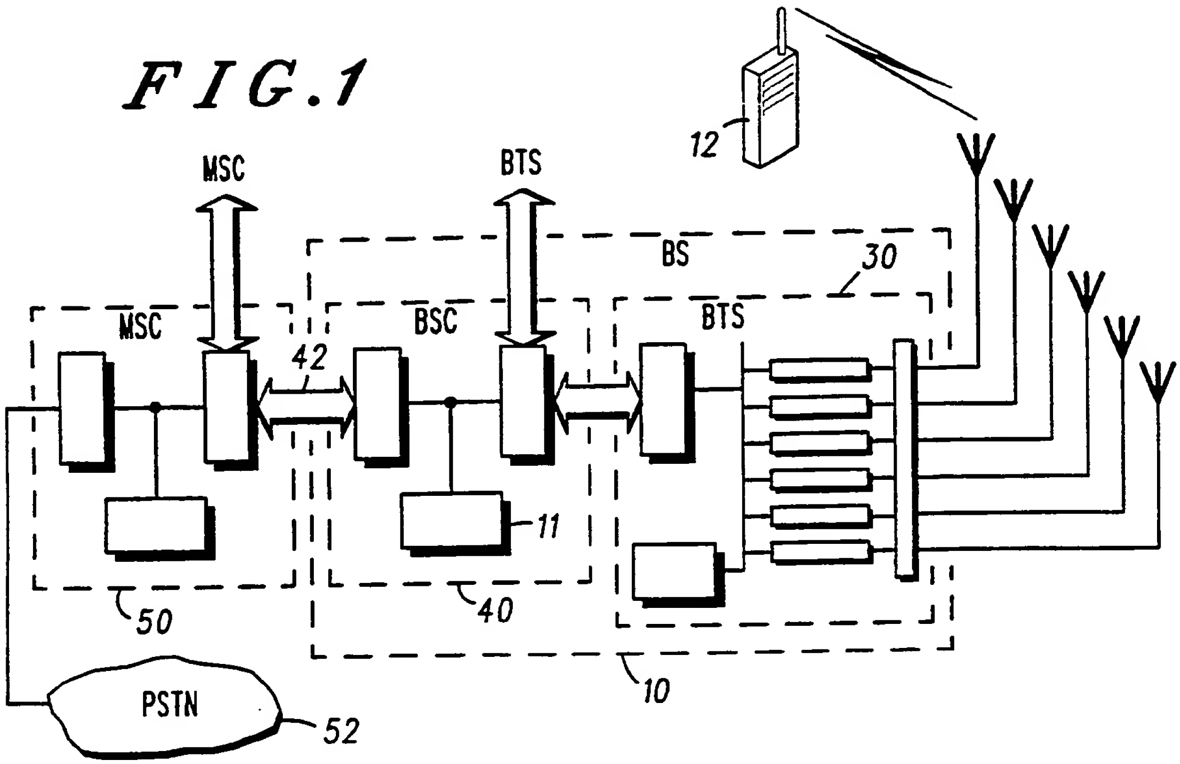
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG.1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PSTN
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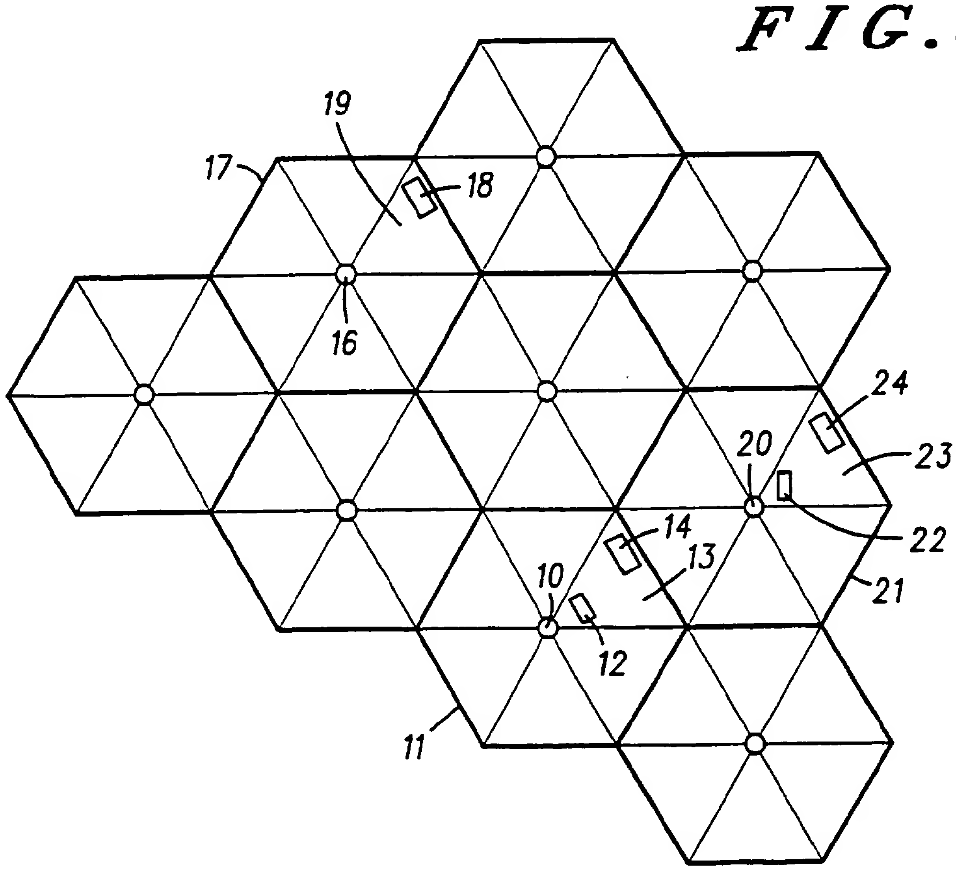
FIG.3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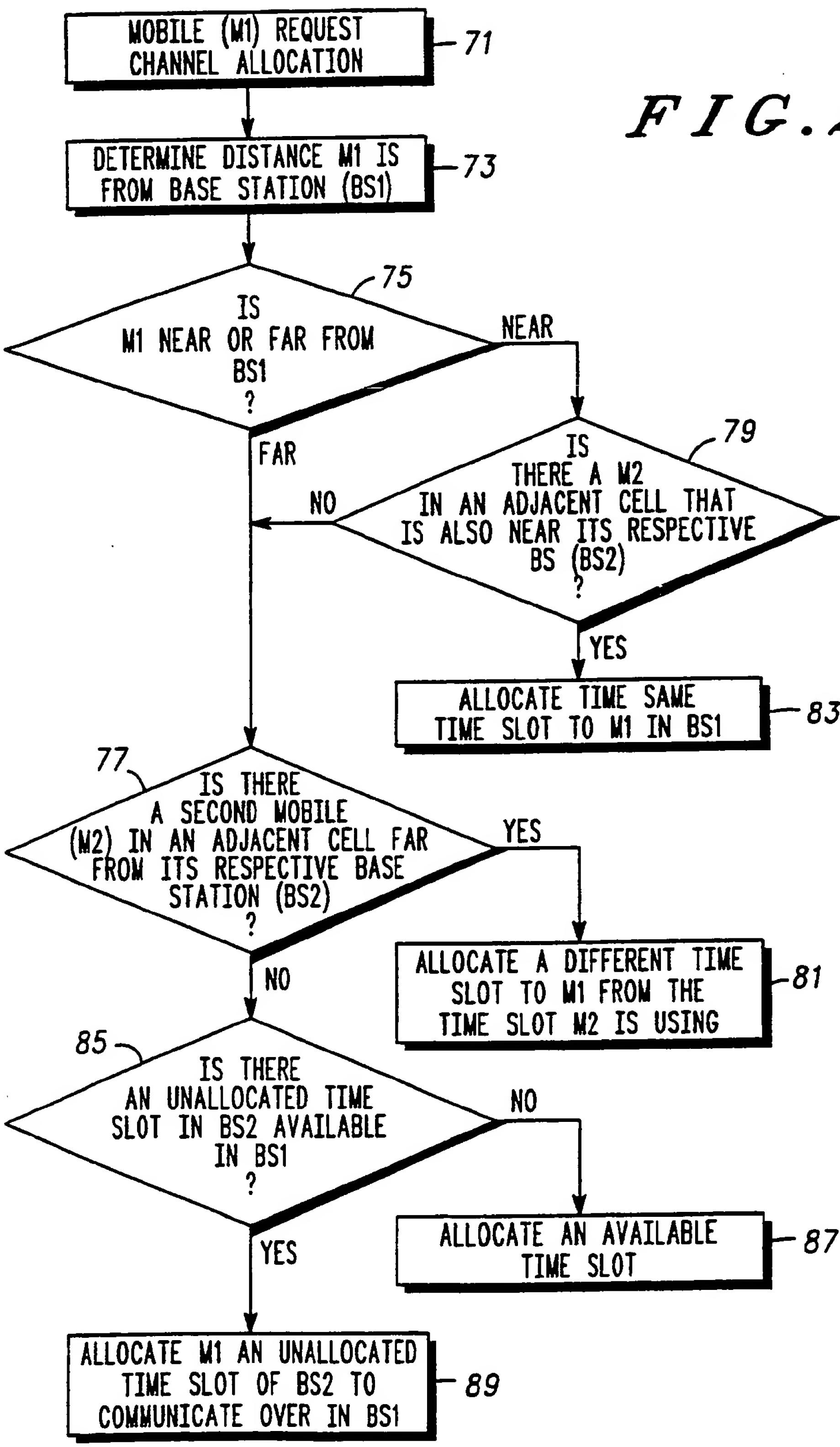
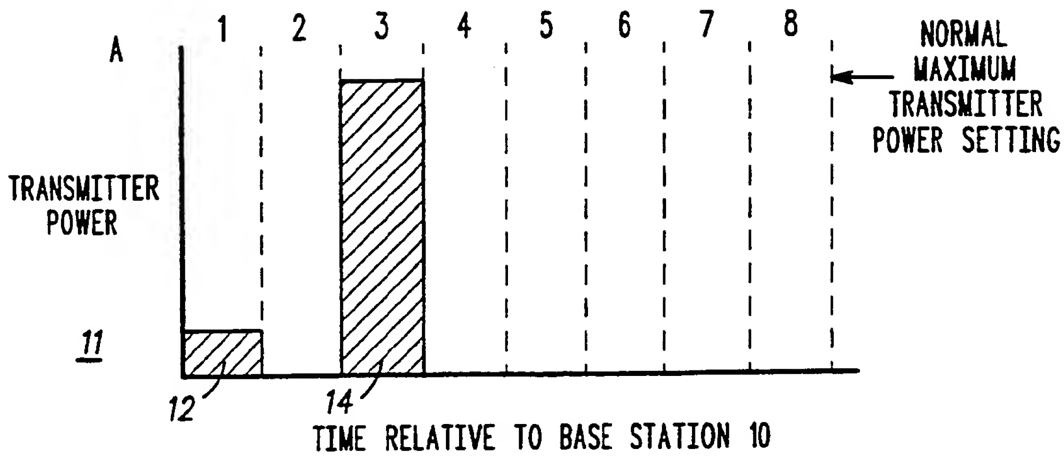

MOBILE (M1) REQUEST CHANNEL ALLOCATION
71
DETERMINE DISTANCE M1 IS FROM BASE STATION (BS1)
73
IS M1 NEAR OR FAR FROM BS1 ?
75
NEAR
FAR
IS THERE A M2 IN AN ADJACENT CELL THAT IS ALSO NEAR ITS RESPECTIVE BS (BS2) ?
79
NO
YES
ALLOCATE TIME SAME TIME SLOT TO M1 IN BS1
83
IS THERE A SECOND MOBILE (M2) IN AN ADJACENT CELL FAR FROM ITS RESPECTIVE BASE STATION (BS2) ?
77
YES
NO
ALLOCATE A DIFFERENT TIME SLOT TO M1 FROM THE TIME SLOT M2 IS USING
81
IS THERE AN UNALLOCATED TIME SLOT IN BS2 AVAILABLE IN BS1 ?
85
NO
YES
ALLOCATE AN AVAILABLE TIME SLOT
87
ALLOCATE M1 AN UNALLOCATED TIME SLOT OF BS2 TO COMMUNICATE OVER IN BS1
89

FIG. 2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8
NORMAL MAXIMUM TRANSMITTER POWER SETTING
TRANSMITTER POWER
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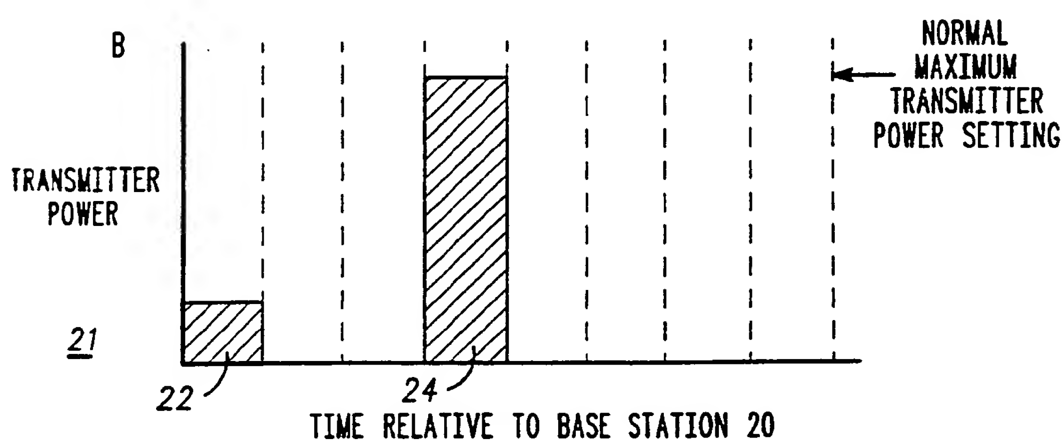
12
14
TIME RELATIVE TO BASE STATION 10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NORMAL MAXIMUM TRANSMITTER POWER SETTING
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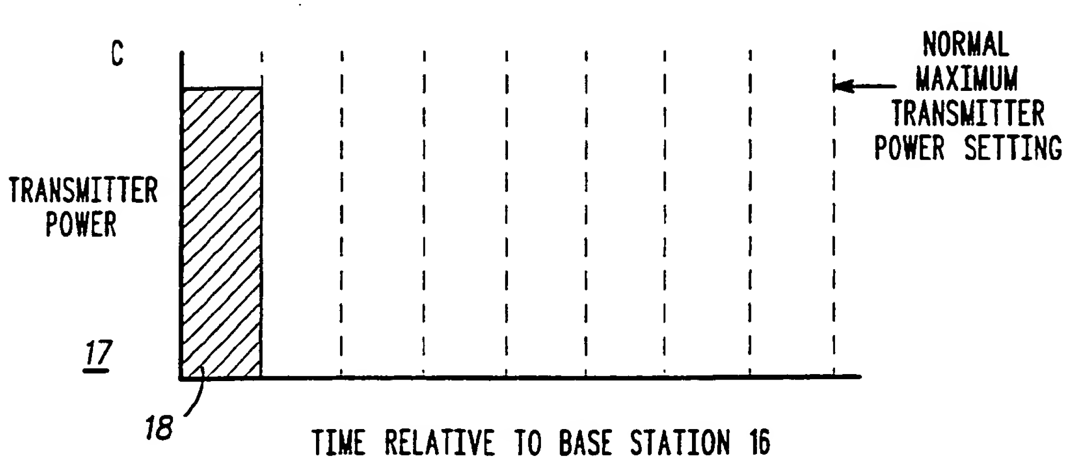
TIME RELATIVE TO BASE STATION 20


C
NORMAL MAXIMUM TRANSMITTER POWER SETTING
TRANSMITTER POWER
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TIME RELATIVE TO BASE STATION 16

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COMMUNICATIONS SYSTEM

Field of the Invention

This invention relates in general to a communications system such as a cellular radio communications system, and more particularly to an apparatus and a method for allocating a communications resource in a communications system.

Background to the Invention

Cellular radio systems make efficient use of a small allocated section of the radio spectrum through their ability to reuse frequencies for several communications simultaneously. The capacity (number of users) of a cellular system is determined by the number of cells and the number of Radio Frequency (RF) carriers available in those cells. If only a few frequencies are available within a system, the size of the cells and the number of times frequencies can be reused is key to providing sufficient capacity.

The reuse of frequencies is determined by the levels of interference that can be tolerated by other users in the system. A nearby transmitter operating on the same frequency as another will cause a mobile or base station to receive high levels of signal from both transmitters and thus the traffic that the station is carrying will suffer from interference. This is known as co-channel interference. There exist several techniques already for minimising this co-channel interference, such as carefully controlling the radiation patter of antennas and the power each transmitter radiates.

EP-A-0,544,095 describes a method of reducing interference within a cellular radio system by partitioning a designated frequency spectrum within a cell into annular sub-cells that is to say different frequencies are allocated to different annular rings around the base station, i.e. depending on the distance from the base station. The arrangement described may be frequency division multiple access (FDMA), direct sequence spread spectrum (DSSS), code division multiple access (CDMA) or time division multiple access

(TDMA). The innermost subcells of adjacent cells are allocated non-coincident spectrum.

There is a need for even more compact frequency reuse to achieve greater capacity on a system without degrading signal-to-noise ratio. Additionally, it would be desirable to provide a scheme that can increase frequency reuse within an existing radio telephone system, such as a digital cellular radio telephone system, without the need for extensive frequency planning or reassignment.

Summary of the Invention

According to a first aspect of the present invention, there is provided a method for allocating a communications resource for at least a first mobile unit in a communications system including at least a first base station where the first mobile unit communicates to the first base station over a communications resource. The method includes measuring a parameter of the first mobile unit and allocating a communications resource for the mobile unit to communicate over on the basis of the parameter.

In a preferred embodiment, the communications system includes a second mobile unit and a second base station communicating on the same communications channel as the first mobile unit and first base station and the method includes receiving a request at the second base station from the second mobile unit for a communications resource, measuring a parameter of the second mobile unit received at the second base station, and allocating a communications resource for the second mobile unit based on the parameter of the second mobile unit and the parameter of the first mobile unit.

According to a second aspect of the present invention, a communications system is provided including at least first and second base stations arranged for communication with at least first and second mobile units respectively over a communications resource where each base station has means for monitoring parameters of signals transmitted by its respective mobile unit and each base station has means for assigning communications resources to different mobile units based on the measured parameters.

In a preferred embodiment, the communications system includes means for exchanging information between the first and second base stations as to the parameters measured by their respective mobile units and the communications resources allocated to those mobile units. In a second embodiment, a control means in the first base station allocates a communications resource to the first mobile unit for communicating with the first base station as a function of the parameter transmitted by the second mobile unit to the second base station and the communications resource allocated to the second mobile unit by the second base station.

Brief Description of the Drawing

FIG. 1 is a block diagram of infrastructure for a communications system according to the present invention.

FIG. 2 is a flow chart for a preferred embodiment of a method of the present invention.

FIG. 3 shows a cell structure including mobile units in the communications system of FIG. 2.

FIG. 4 shows time slots for allocation for the mobile units of FIG. 3.

Detailed Description of the Preferred Embodiment

Referring to FIG. 1, a block diagram of infrastructure for a digital communications system is shown. The infrastructure includes a base station 10 and a mobile switching centre 50. The base station 10 includes a base station controller 40 and at least one base transceiver station 30. The base transceiver station 30 communicates to a mobile unit 12 within a cell. The base transceiver station 30 is controlled by a base station controller 40. The base station controller 40 allocates communications resources to mobile units in its respective cell area. According to the present invention, the base station controller 40 includes a control means 11, such as a microcontroller or microprocessor, to allocate communications resources to mobile units within the respective cell area of the base station controller 40. Communications resources

include frequencies and time slots for mobile units to communicate over to the base station controller 40.

The base station controller 40 communicates via a mega stream link 42 to a mobile switching centre 50. The mobile switching centre 50 typically routes handoffs and other aspects of overall traffic management. The mobile switching centre 50 also communicates to the public service telephone network 52 typically over a land line 51.

The communications system includes the ability to control transmitting power. Controlling transmitting power includes measuring the received signal levels and adjusting power accordingly. Received signal strength indicator circuits are used typically used.

A base transceiver station 30 measures a received signal power level from a mobile unit 12, compares it against a desired signal power level and sends an error signal back to the mobile unit 12 to indicate to the mobile unit 12 how to correct the mobile's transmit power. Similarly, the base transceiver station's transmit power is controlled. Thus, a base transceiver station 30 controls output transmit power of the mobile unit 12 and likewise the mobile unit 12 controls the output transmit power of the base transceiver station 30.

Typically the output transmit power is controlled in order to limit transmitted power to a minimum level required for a good quality link and to minimise interference from other transmitters in the system using the same radio frequency. The closer the mobile is to the base station 10, the less power is needed for transmitting to and from the mobile unit 12. A mobile that is located farther away from the base station 10 or on a cell boundary requires more transmitting power. Power control information may be gathered at the base station 10 and then shared with other base stations directly or via the mobile switching centre 50.

FIG. 2 is a flow diagram that illustrates a method for allocating a communications resource, such as time slots in a TDMA communications scheme, according to one aspect of the present invention. In a preferred embodiment of the present invention, a

first mobile requests a channel allocation from a base station in step 71. A distance or relative distance between the mobile and the base station based on a power control signal is determined in step 73. The method includes determining that mobiles transmitting over a selected maximum power level are transmitting with high power and thus are far away from the base station. For example, if the mobile unit's transmit power is less than 10 db below the mobile unit's maximum transmit power then the mobile unit is transmitting with high power. Likewise, if the mobile unit is transmitting with more than 10 db below its maximum transmit power then the mobile unit is transmitting with low power and is close to the base station in step 75.

In a preferred embodiment of the present invention, a distance is calculated from the power control signal. Power levels of mobile units and base stations are determined based on the cellular system itself considering such variables such as cell size, power classes of mobiles.

A maximum transmit power may be measured at a moment of handoff because theoretically the mobile unit would be transmitting at the cell boundary transmitting with maximum power to one base station just before handing off to a second base station.

A minimum power received would be a minimum power recorded closest to the base station. Once a mobile unit's transmit power is known at a cell boundary and at a minimum possible distance at the base station, then an approximation distance for any mobile unit operating between the maximum and minimum distance may be calculated.

In GSM, a timing advance parameter is determined at the base station and sent to the mobile unit to inform the mobile unit how far in advance to send its signal to be able to be received in the allocated time slot at the base station. The timing advance parameter represents distance between a mobile unit and a base station more accurately than calculating a distance from a received power signal and as such may be used to determine a relative distance between the mobile unit and the base station for the present invention.

If the first mobile is found to be far away from the base station then step 77 determines whether there is a second mobile operating with high power and thus also operating far from its respective base station. This may be determined by comparing the power level signals of mobile units in neighbouring cells gathered by the respective base stations and passed to the neighbouring base stations directly or via the mobile switching centre. The allocation of the frequencies and time slots of neighbouring cells are shared and monitored by each base station. By monitoring the traffic in neighbouring cells, time slots may then be allocated to minimise interference. Base stations may monitor the traffic and allocation of time slots in their particular cell and pass information to base stations in neighbouring cells for allocation of time slots. The base station makes channel allocations based on the information passed from the neighbouring base stations detailing the allocation of time slots in the neighbouring cells.

In most digital communications systems, neighbouring base stations are constantly monitoring received signals from mobile units in neighbouring cells in order to perform handovers. Based on such signals the approximate location of a mobile unit in relation to its neighbouring cell may be determined. Thus, it may be determined if the mobile unit is operating on a cell boundary and which cell boundary the mobile unit is operating on.

If a first mobile unit is operating at a high power level on a neighbour's cell boundary then a decision not to allocate a same time slot to a second mobile unit operating in the same cell or neighbouring cell as the first mobile unit. However, if the first mobile unit is operating at a high power level but not on a neighbouring cell boundary than if necessary a same time slot may be allocated to the first mobile unit as a second mobile unit in the neighbouring cell. By monitoring mobile units in neighbouring cells an intelligent decision may be made on how to allocate time slots to requesting mobile units to minimise interference.

According to a preferred embodiment of the present invention, if the first mobile unit is operating at a high power far from its respective base station (first base station) and there is a second

mobile unit in an adjacent cell operating at high power and thus also far from its respective base station (second base station) on the same frequency, then the first mobile unit will be allocated in step 81 a different time slot from the time slot that the second mobile unit is using.

If there is not a second mobile unit in an adjacent cell operating far from its respective base station then the traffic in the second cell may be analysed in step 85 to determine whether there is an unallocated time slot in the second base station that is available in the first base station. If there is an unallocated time slot in the second base station that is available in the first base station then in step 89 it is allocated to the first mobile unit. If not, then the first mobile unit is allocated the next available time slot in step 87.

If the first mobile unit is determined at step 79 as operating near to its respective base station (first base station) and there is a second mobile unit in an adjacent cell operating at low power and near to its respective base station (second base station) on the same frequency then in step 83 the first mobile unit will be allocated the same time slot as the time slot that the second mobile unit is using.

If the first mobile unit is operating near to its respective base station (first base station) and there is a second mobile unit in an adjacent cell operating at high power or far from its respective base station (second base station) on the same frequency as determined at step 79, then in step 81 the first mobile unit will be allocated a different time slot from the time slot that the second mobile unit is using.

If there is not a second mobile unit in an adjacent cell operating far from its respective base station then the traffic in the second cell may be analysed in step 85 to determine whether there is an unallocated time slot in the second base station that is available in the first base station.

If there is an unallocated time slot in the second base station that is available in the first base station then in step 89 it is allocated to the first mobile unit. If not, then in step 87 the first mobile unit is allocated any available time slot.

FIG. 3 illustrates a cellular communications system having a number of mobile units operating in different cells. The cells are divided into six sectors for transmitting on six different frequencies.

FIG. 3 shows a first mobile unit 12 being served by a first base station 10 located in the centre of a first cell 11. The first mobile unit 12 is located relatively close to the first base station 10 and operating on a first frequency in a sector 13 of the first cell 11. The first mobile unit 12 is transmitting and receiving on low power.

Similarly, a second mobile unit 22 is located near a second base station 20 in a sector 23 of a second cell 21. The second mobile unit 22 is operating on the same frequency as the first mobile unit and is transmitting and receiving to the second base station 20 on low power.

In contrast, a third mobile unit 14 is located on a cell boundary in the first cell 11 and in order to transmit to and receive from the first base station 12, of the first cell 11, it must operate with high power. Similarly, a fourth mobile unit 24 is located on a cell boundary in the second cell 21 and must operate with high power to transmit to and receive from the second base station 20 of the second cell 2.

Also shown is a fifth mobile unit 18 located in a sector 19 on the cell boundary of a third cell 17. The fifth mobile unit 18 is also operating with high power in order to transmit to and receive from a third base station 16 of the third cell 17.

FIG. 4 shows time slots of a TDMA communications system allocated according to the present invention for the cells of FIG. 3.

FIG. 4a shows transmitting power for the first cell 11 of FIG. 3. A first time slot of FIG. 4a, shows the transmitting power of the first mobile unit 12. Since the first mobile unit 12 is near the base station 10 it is transmitting at low power.

In time slot 3 of FIG. 4a, transmit power of the third mobile unit 14 is shown. Since the third mobile unit is far from the base station 10 it is transmitting at high power.

Similarly, FIG. 4b shows transmitting power for the second cell 21 having mobile units 22, 24 on the same frequency as the first cell 10. The second mobile unit 22 transmit power is shown in the first

time slot of FIG. 4b. Since the second mobile unit 22 is operating with low power it may be allocated the same time slot as the first mobile unit 12.

The fourth mobile unit 24 transmit power is shown in the fourth time slot. The fourth mobile unit is operating at high power and must be allocated a different time slot from that of the third mobile unit 14 of the first cell 11.

FIG. 4c shows a transmit power for the fifth mobile unit 18 in the third cell 17. Since the fifth mobile unit 18 is far from the base station 16 of the third cell 17 it must transmit with high power. But since the third cell 17 is some distance from the first and second cells 11, 21 it does not matter if the time slot allocated is similar to an allocated time slot of the first or second cells 11, 21.

Thus there is provided a dynamic system in which base stations inform each other as to the current state of allocation of communications resources within their coverage areas and adjacent base stations decide upon their resource allocation according to the allocation resources in surrounding cells.

In particular, the arrangement enables the possibility that, and indeed it is preferred that, where a mobile unit is communicating at low power with a first base station on a first frequency, a second adjacent or approximate base station allocates the same frequency to a mobile unit for communication at low power with the second base station.

This arrangement can be tolerated because the two mobile units operating on the same frequency are operating at low power, close to their respective base stations. By contrast, mobile units operating at high power in adjacent or proximate cells are allocated different frequencies, because these mobile units are operating near the boundaries of their respective cells and may interfere with each other.

The exemplary system is a TDM system in which the communications resource is divided into time slots allocatable to different mobile units. In such a system, it is preferred that a mobile unit requiring allocation of a time slot is allocated a time slot according to the following rules; if the mobile unit is able to operate

at low power, it may be allocated a time slot which is simultaneously in use by another mobile unit in an adjacent or proximate cell, whereas if the mobile unit requires communication at high power, it may be allocated a time slot that is, at the time of allocation, not in use in an adjacent or proximate cell. If the mobile unit requires communication at high power and all time slots in adjacent cells are in use, the mobile unit is allocated a time slot on another frequency which is not used by adjacent or proximate base stations.

Thus, it can be seen that a system is provided where it is tolerated that adjacent or proximate base stations use communications resources in common. It is preferred that in addition to the common communications resources, each base station has communications resources which are unique to that base station in the vicinity. The unique communications resources are reserved for use only in heavy loading by preferentially allocating the common communications resources to mobile units operating at low power.

Claims

1. A method for allocating a communications resource for at least a first mobile unit in a communications system including at least a first base station where the first mobile unit communicates to the first base station over a communications resource comprising the steps of:

receiving a request at the first base station from the first mobile unit for a communications resource allocation;

measuring a parameter of the first mobile unit received at the first base station; and

allocating a communications resource for the mobile unit on the basis of the parameter.

2. The method of claim 1 further comprising the steps of:

receiving a request for a communications resource at a second base station from a second mobile unit communicating on a same communications channel as the first mobile unit;

measuring a parameter of the second mobile unit received at the second base station; and

allocating a communications resource for the second mobile unit based on the parameter of the second mobile unit and the parameter of the first mobile unit.

3. The method of claims 1 or 2 wherein the parameter is a power level signal.

4. The method of claims 1 or 2 wherein the parameter is a timing advance signal.

5. The method of any preceding claim wherein the communications resource is a channel time slot.

6. A communications system comprising at least first and second base stations arranged for communication with at least first and second mobile units, respectively, over a communications resource,

each base station comprising means for monitoring parameters of signals transmitted by its respective mobile units and each base station having means for assigning communications resources to different mobile units characterised by means for exchanging information between the first and second base stations as to the parameters transmitted by their respective mobile units and the communications resources allocated to those mobile units and control means in the first base station for allocating a communications resource to the first mobile unit for communicating with the first base station as a function of the parameter of a signal transmitted by the second mobile unit to the second base station and the communications resource allocated to the second mobile unit by the second base station.

7. A communications system according to claim 6 wherein the control means allocates a communications resource to the first mobile unit as a function of the parameter transmitted by the first mobile unit.

8. The communications system of claims 6 or 7 wherein the parameter is a power level signal.

9. The communications system of claims 6 or 7 wherein the parameter is a timing advance signal.

10. A communications system according to claim 8 wherein said control means are arranged to allocate communications resources according to the rule that mobile units transmitting at low power to their respective base stations are allocated the same communications resource.

11. A communications system according to claim 8 wherein the control means are arranged to allocate communications resources according to the rule that mobile units transmitting at high power to their respective base stations are allocated different communications resources.

12. A communications system according to claims 6, 7, 8, 9, 10 or 11 wherein the communications resource is a channel time slot.

13. A method for allocating communications resources for at least a first mobile unit in a communications system including at least a first base station where the first mobile unit communicates to the first base station over a communications resource substantially as herein described with reference to FIG. 2 of the drawing.

Patents Act 1977 **Ex' iner's report to the Comptroller under Section 17** **(Th. Search report)** 14	Application number GB 9326312.7
Relevant Technical Fields (i) UK Cl (Ed.M) H4K (KY4D14, KY4D8D) H4L LDSF	Search Examiner KEN LONG
(ii) Int Cl (Ed.5) H04Q (7/04)	Date of completion of Search 21 APRIL 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE: WPI	Documents considered relevant following a search in respect of Claims :- 1 to 5 and 13

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2260242 A	(ERICSSON) see particularly page 3 line 30 to page 4 line 15 and page 6 line 31 to page 7 line 6	1 and 3
X	EP 0544095 A1	(MOTOROLA) see particularly column 2 lines 42 to 55 column 3 lines 9 to 15, column 4 lines 5 to 17, column 7 line 50 to column 8 line 7 and column 8	1 to 5
X	EP 0430173 A2	(NIPPON) see particularly column 7 lines 22 to 57	1 and 3
X	EP 0419243 A2	(NIPPON) see particularly column 2 line 53 to column 3 line 9	1 and 3
X	WO 92/11736 A1	(ERICSSON) see particularly page 2 lines 31 to 34, page 3 lines 7 to 16, and page 3 line 22 to page 4 line 8	1 and 3
X	WO 91/09474 A1	(NORTHERN TELECOM) see particularly page 1 lines 25 to 28 and page 1 line 34 to page 2 line 24	1 and 3

Databases:The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

FIG.1

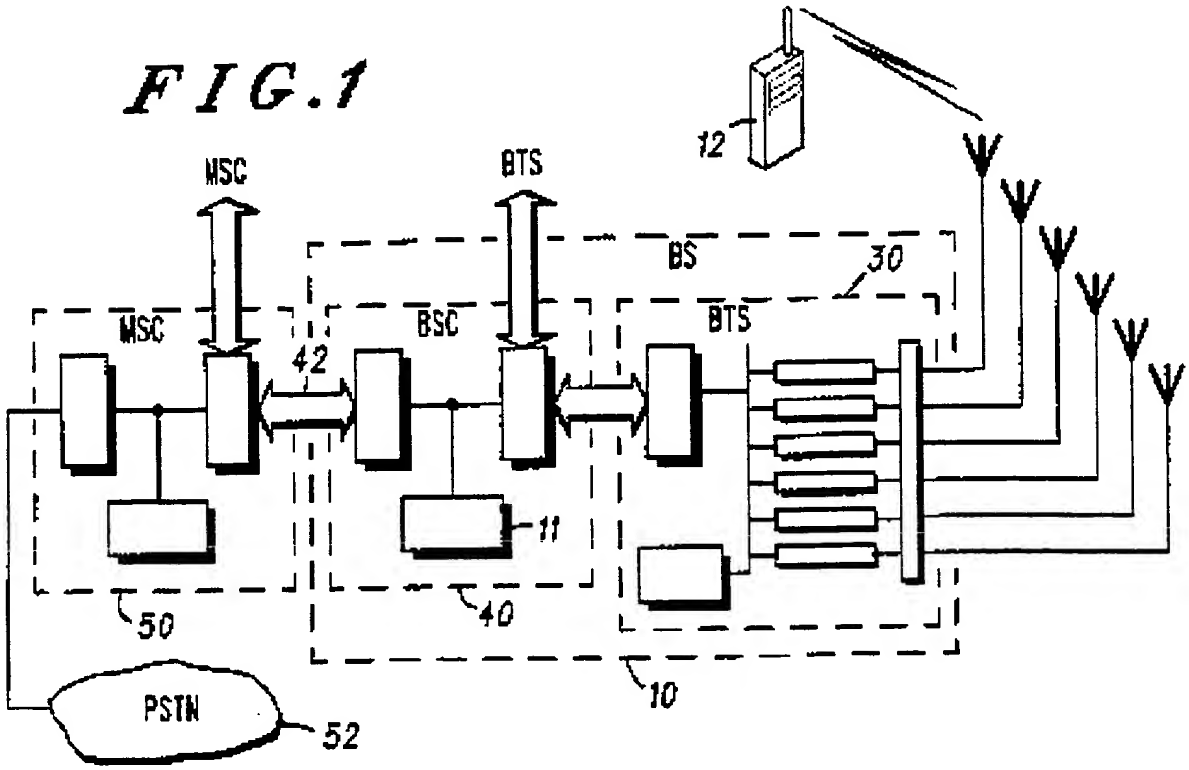
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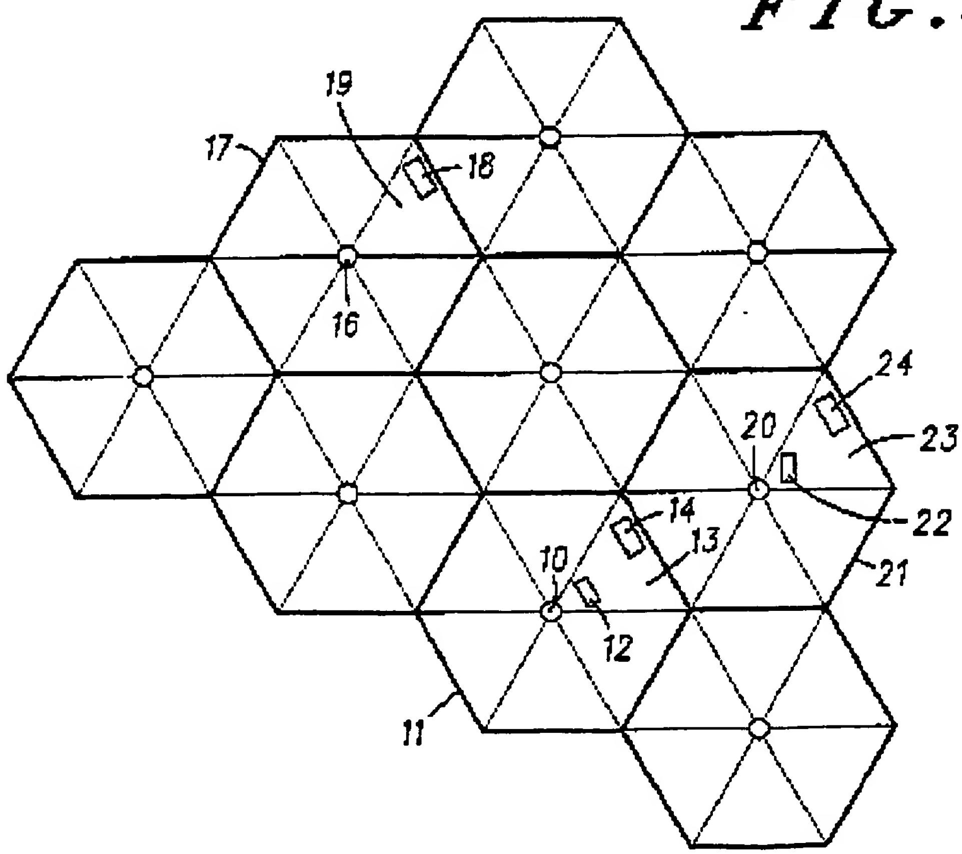
FIG.3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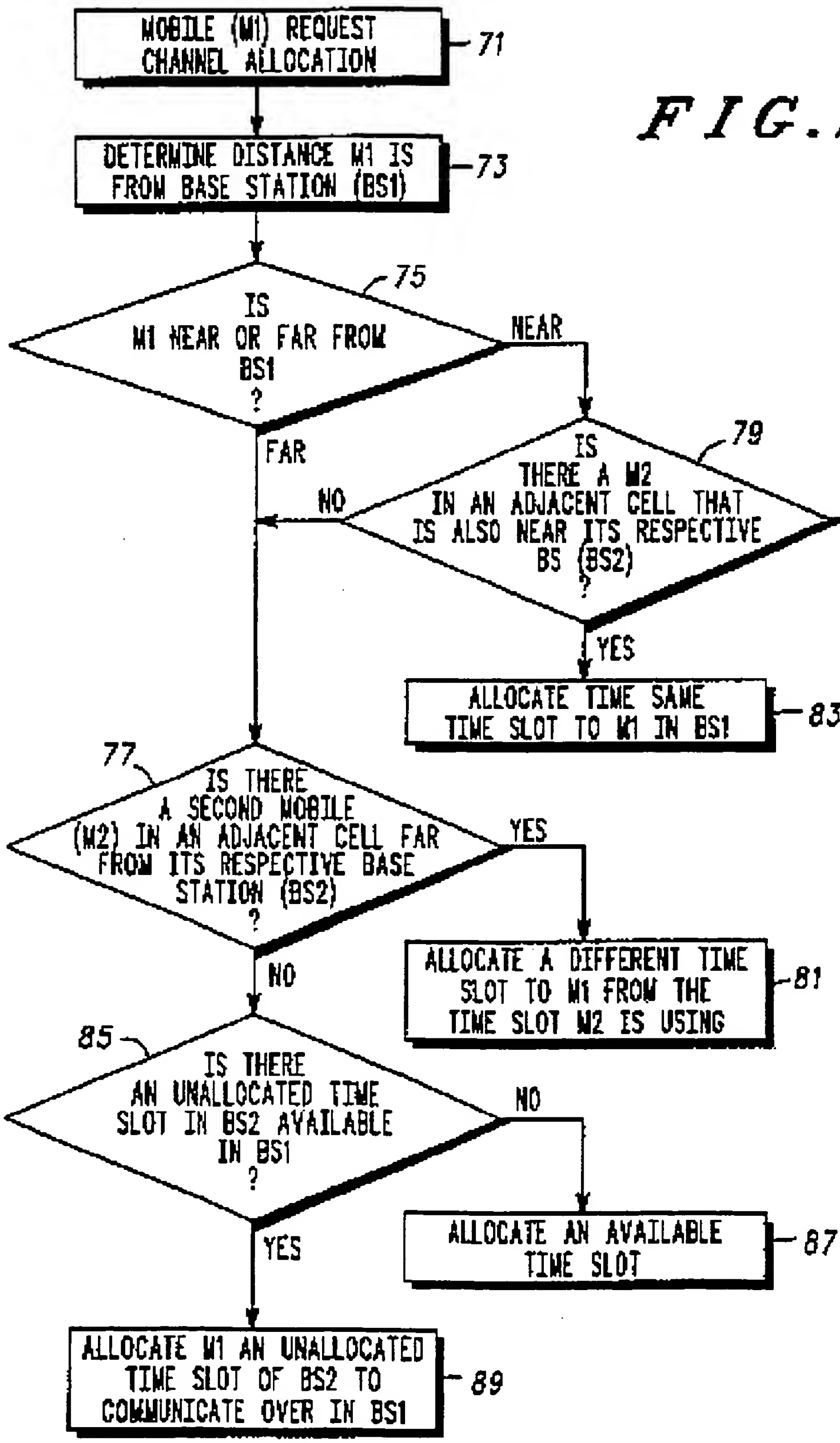
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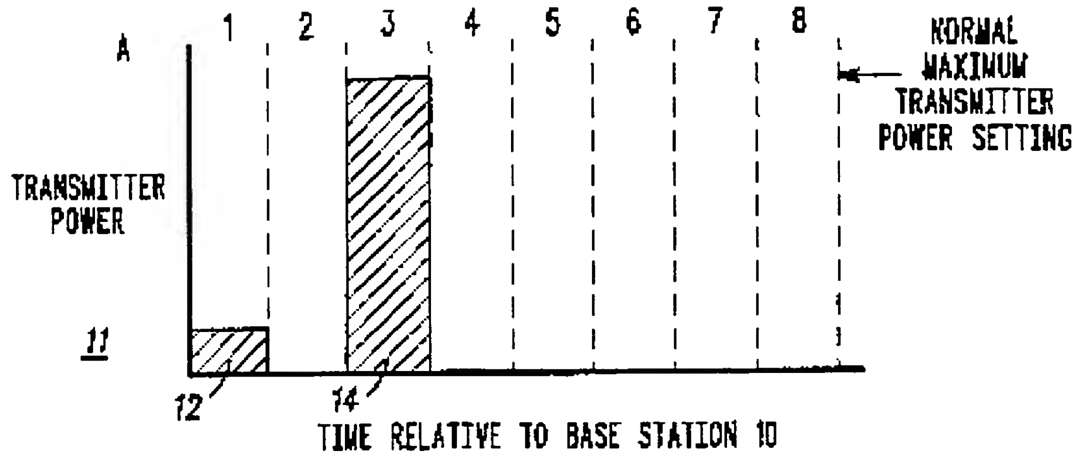
A
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NORMAL MAXIMUM TRANSMITTER POWER SETTING
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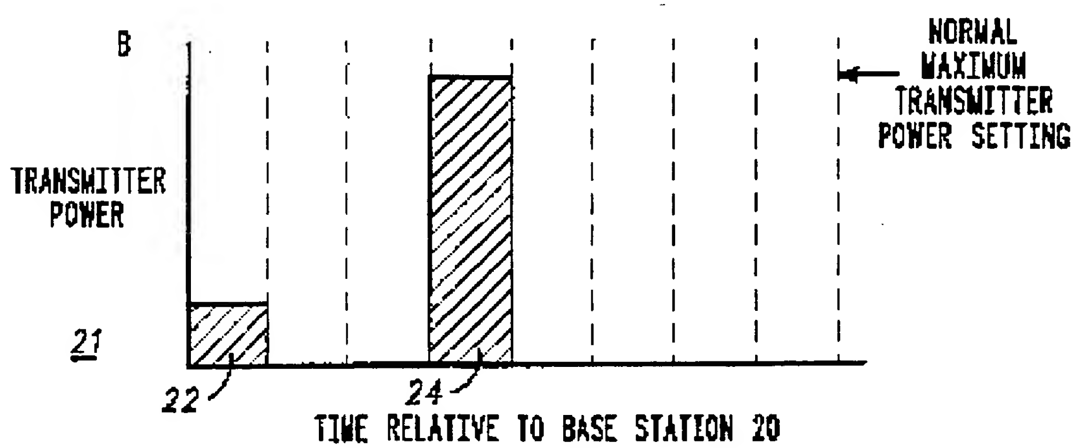
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TRANSMITTER POWER
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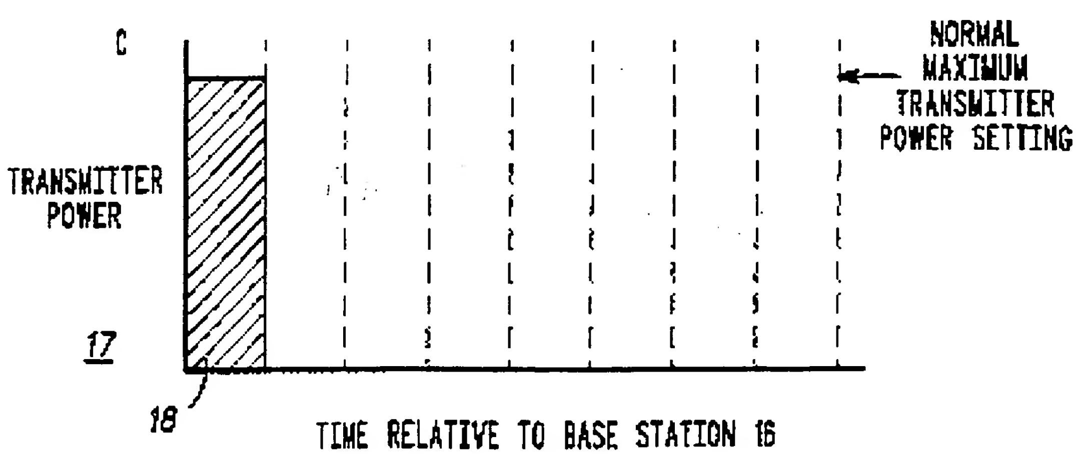
TIME RELATIVE TO BASE STATION 20


C
NORMAL MAXIMUM TRANSMITTER POWER SETTING
TRANSMITTER POWER
17
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TIME RELATIVE TO BASE STATION 16

ORIGINAL
NO MARGINALIA

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